Requirements and Status of the SDSS Spectroscopic Systems

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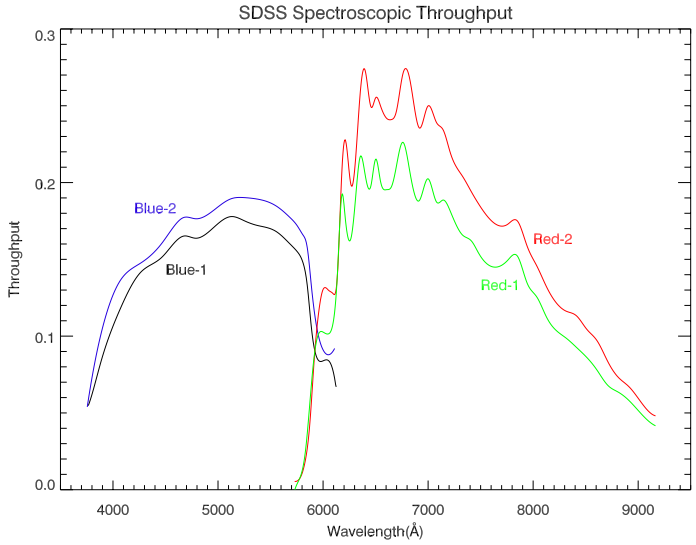
Introduction

The requirements for the spectroscopic data production systems (from instrumentation through to data analysis), as taken from the requirements document (http://www.astro.princeton.edu:81/requirements/scireq/scireq.html), are outlined below. The current status of the production systems are described together with supporting documentation and plans for near-term improvements. The requirements data are based on the analyses of Mariangela Bernardi, Scott Burles, Daniel Eisenstein, David Schlegel and Mark SubbaRao.

Requirement 1: Overall throughput at all wavelengths is 90% of the Black Book value (for 95% of the fibers) Components include fibers, optics, CCDs (not telescope).

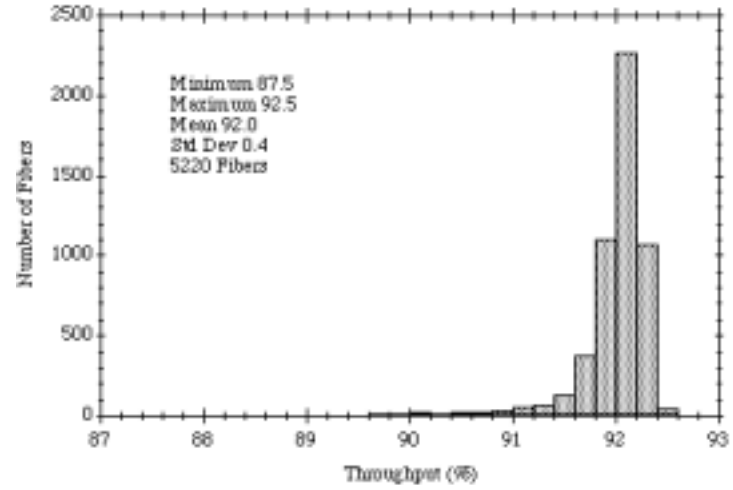
- Throughput (including telescope and atmosphere) is 65% (blue) 75% (red) of the Project Book values. Allowing for atmospheric transmission the the spectrograph throughputs are approximately 80% of the Project book values. This is sufficient to meet the signal-to-noise criteria for the spectroscopic observations.
- Data used to generate these numbers February spectroscopic observations of spectrophotometric standards.
- Plot of throughput (including telescope and atmospheric losses).

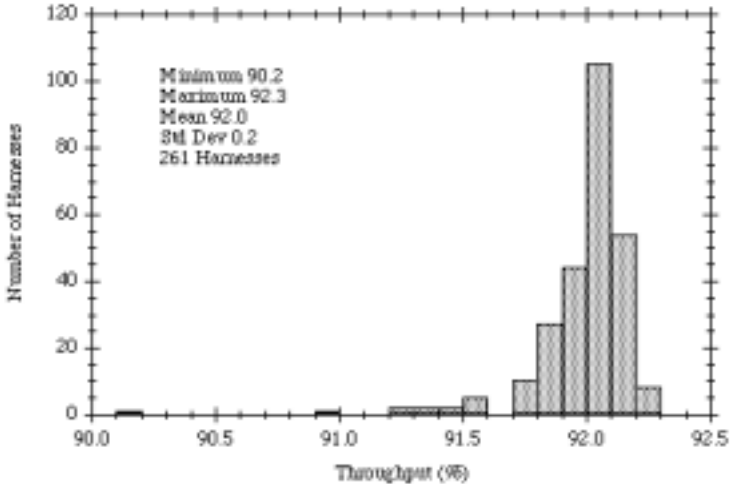


- Throughput will be monitored using the flat fields exposures as a function of cartridge plus measurements of the spectrophotometric standard stars (in photometric conditions). Information required to undertake monitoring is in place. Procedures are not fully defined (for the spectroscopic data analyst).
- There are no known problems with spectrograph throughput.

Requirement 2: Average throughput of the fibers in each harness should exceed 90% with a minimum of 87% (for unbroken fibers).

- Fiber throughputs have a mean of 92% and minimum of 87.5% and thereby meet requirements.
- Data used to generate these numbers are from the SDSS technical note 19980203 by Owen etal.
- Plot of throughput for fibers and harnesses.





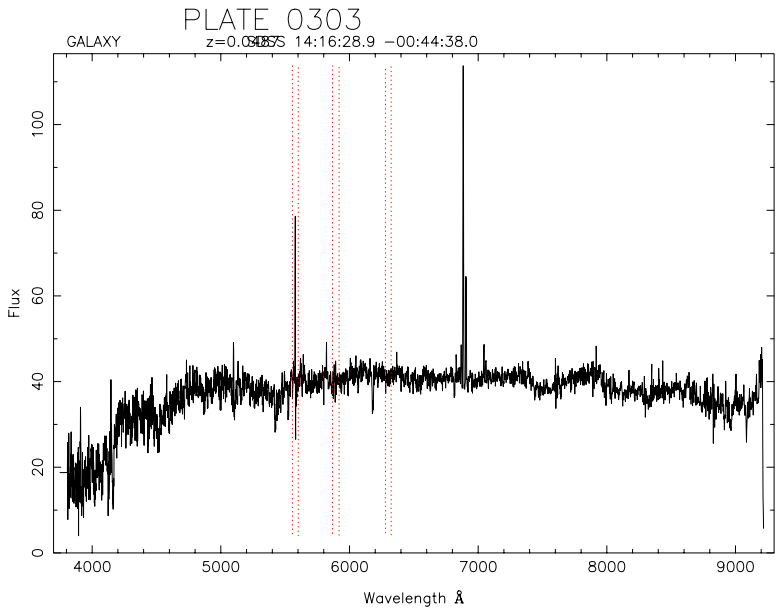
- Throughput of fibers for each cartridge will be monitored through the flatfield observations before and after each exposure. This must be monitored by the spectroscopic data analyst on a monthly basis.
- There are no known problems with fiber throughputs.

Requirement 3: RMS fiber-to-fiber throughput variation of fibers should not exceed 4% at any wavelength.

- Fiber throughput variations have a standard deviation of 0.4% and a minimum of 4.5% (when measured in isolation). As part of the spectroscopic system the variation in fiber throughput is 10% across the full spectral range.
- Data used to generate these numbers are from the SDSS technical note 19980203 by Owen etal and the 2D spectroscopic outputs.
- Throughput of fibers for each cartridge will be monitored through the flatfield observations before and after each exposure. This must be monitored by the spectroscopic data analyst.
- There are no known problems with fiber throughput. variations.

Requirement 4: Spectrographs should have continuous coverage from 3900-9100 A.

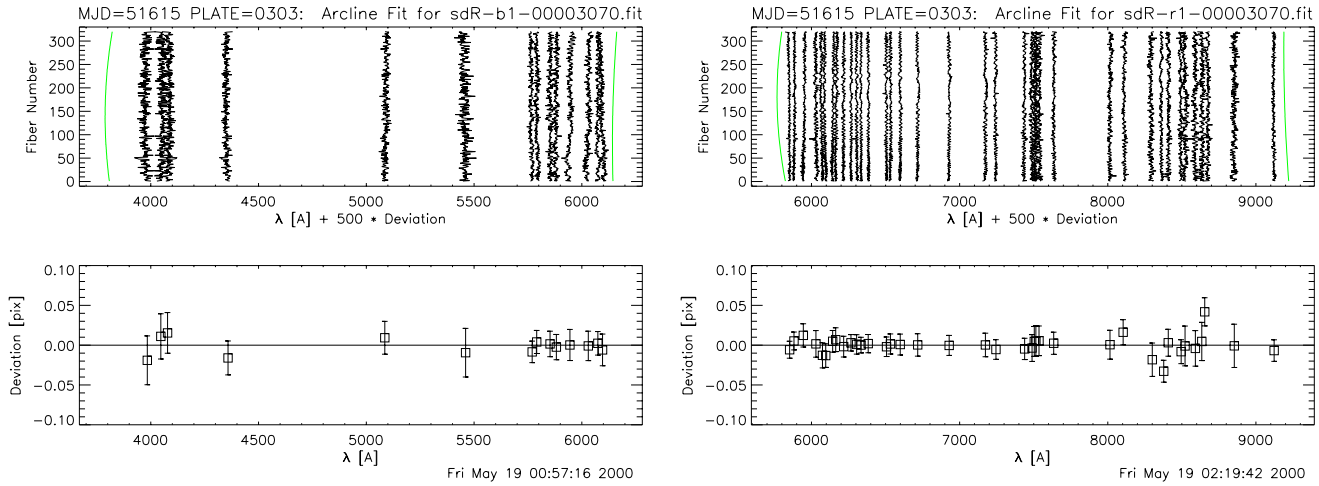
- Spectrographs have continuous coverage from 3790-9200 Å.
- Data used to generate these numbers are the March-May observing run reductions.
- Plot of spectrum from plate 303.



- Wavelength coverage will be monitored and adjusted during the shakedown period at the start of each run. Procedures for collimating and focusing the spectrographs are in place.
- There are no known problems with wavelength coverage.

Requirement 5: RMS deviation of the measured wavelength scale from arc lines should be less than 0.1 A (blue) and 0.2 A (red) for all fibers over the full spectra range.

- Rms deviation is <0.05 A in blue and red.
- Data used to generate these numbers are the March-May spectroscopic observations.
- Plot of rms wavelength solutions.



- The rms deviation in the wavelengths of arc lines as a function of wavelength (arc line) is an output of the spectroscopic pipeline and will be monitored by the spectroscopic data analyst.
- There are no known problems with wavelength solutions for the arc lines.

Requirement 6: FWHM of unblended arc lines, in pixels, in a given fiber will have an rms dispersion of less than 5% of the mean FWHM.

- Variation in FWHM of arc lines has a peak excursion of approximately 10–20%. The FWHM are not random, always narrower in the center of the CCD, and wider towards the edges. This does not significantly impact the 2D reduction software.

fiber RMS	Mean	Min	Max
b1	0.0767227	0.0668391	0.1017860
b2	0.0354852	0.0277687	0.0434206
r1	0.0413154	0.0225156	0.0523931
r2	0.0441674	0.0360763	0.0509661

- Data are taken from Plate 0280, exposure 2924.
- Focus of the spectrographs is performed prior to each dark run.
- There are no known problems.

Requirement 7: FWHM of unblended arc lines, in pixels, at a given wavelength will have an rms dispersion of less than 5% of the mean FWHM.

- Variation in FWHM of arc lines as a function of wavelength is on the order of 1-2 % (rms).

RMS vs lambda	Mean FWHM(pix)	Mean (RMS)	Min	Max
b1	2.32464	0.0208945	0.0181424	0.0293862
b2	1.92111	0.0180777	0.0146962	0.0200569
r1	1.88836	0.0168787	0.0105677	0.0230930
r2	1.94232	0.0221923	0.0138888	0.0447434

- Data are taken from Plate 0280, exposure 2924.
- The focus of the spectrographs are monitored on a monthly basis. Each dark run the spectrographs are refocussed as part of the shakedown period. The procedures for this are in place and operational.
- There are no known problems with the focus/FWHM of arc lines.

Requirement 8: FWHM of unblended sky lines in all spectra will be less than 1.05x that of the arc lines in the same part of the spectrum.

- All spectra are extracted from a 15 min exposure before coadding. Flexure in a 15 min exposure amounts to approximately 1/4 pixel. This is approximately a factor of 4 below that required to produce a 5% effect in the FWHM of sky lines.
- There are no known problems.

Requirement 9: The minimum spectral resolution in a 15 minute exposure at any wavelength in any fiber is 1800.

- Spectral resolution is approximately 1859 at 5577 A in the blue spectrograph and 2200 at 8829 A in the red.
- Data used to generate these numbers are the March-May spectroscopic observations.
- There are no known problems though this requires testing for all cartridges.

Requirement 10: Flat fielding must be insensitive to any flexure.

- Flatfielding is done for each exposure using two mechanisms. The pre- and post- calibration flat fields provide the overall spectral response of the fibers and a uniformly illuminated flat provides pixel to pixel response.
- Uniformly illuminated flat fields are generated during each shakedown period at the start of each run by moving the collimator mirror. Procedures are in place and operational.
- There are no known problems in flat fielding.

Requirement 11: Cross talk between adjacent fibers must be less than 1%. [This requires a redefinition to provide a definition for a point source at the brightest limit for target selection].

- For a Gaussian fiber profile with a 1 pixel dispersion the 6.1 pixel separation between fibers give a cross talk area of $>$1% of the total flux. For bright sources the profile wings are not Gaussian but exponential with a 25 pixel decay.

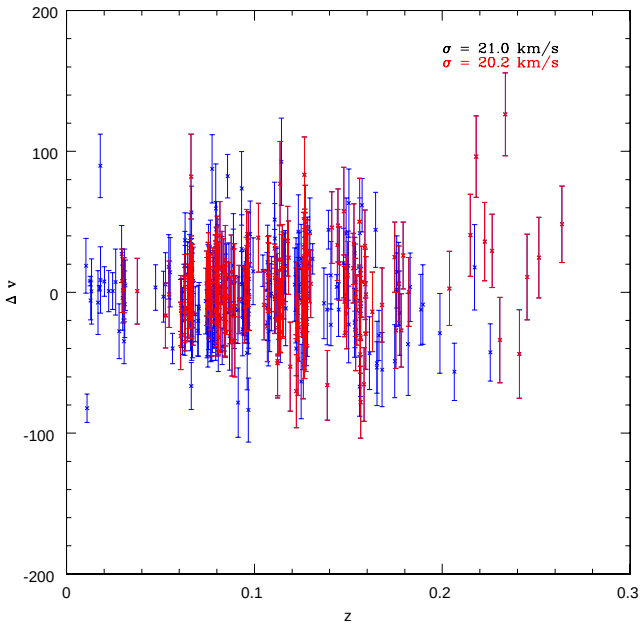
- Extremely bright sources (<14th magnitude point sources) are not targeted.
- There are no known problems.

Requirement 12: Coaddition of 3×900s of an elliptical galaxy with r$_{fiber}$ <19.5 (observed in photometric conditions) will yield a redshift with an rms statistical error of 30 km/s. [This defines an internally repeatable redshift measurement).

- The rms redshift error for all galaxies within the target selection limit is approximately 30 km/s at a signal to noise of 9 per pixel. At these limits 3 - 5 % of redshifts are not repeatable (i.e. deviate by more than 3 σ).

Plate	MJD	$SN^2_{g'(1,2)}$	$SN^2_{r'(1,2)}$	$SN^2_{i'(1,2)}$
282	51630	28.2 37.1	36.2 40.3	39.4 35.9
282	51658	140.8 169.7	156.6 187.1	136.4 154.9
RMS 37 km/s.				
295	51581	27.3 24.1	35.8 25.0	30.0 19.5
295	51585	82.8 66.3	73.6 53.8	59.6 41.3
RMS 31 km/s.				
296	51578	89.0 79.3	85.1 52.7	74.2 41.8
296	51665	73.0 71.5	83.0 72.5	69.4 58.9
RMS 28 km/s.				
348	51671	148.6 153.3	163.3 173.0	126.5 141.2
348	51696	112.3 108.2	155.8 146.8	149.7 145.7
RMS 22 km/s.				
349	51692	97.1 100.9	126.6 129.7	127.0 122.9
349	51699	134.7 136.5	170.4 178.6	163.4 168.4
RMS 19 km/s.				
353	51696	54.8 61.0	72.0 77.7	72.1 73.4
353	51700	66.3 63.4	88.6 83.1	83.2 72.1
RMS 27 km/s.				

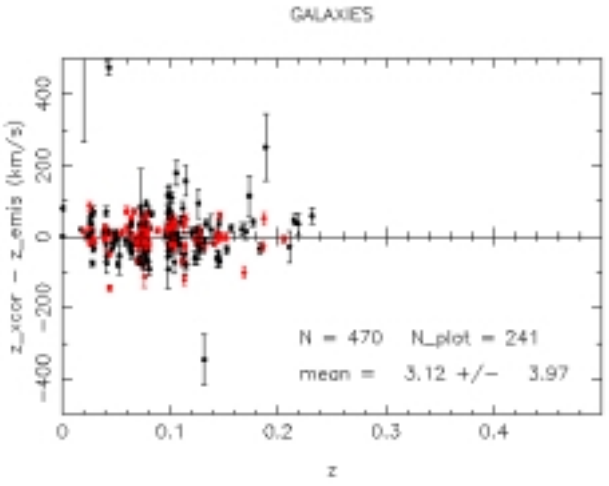
- This result is based on the repeated observations of plates 282, 295, 296, 348, 349, 353.
- Repeatability of Plate 353 (observed on nights MJD51696 and MJD 51700).



- Repeat observations of a small subset of plates periodically throughout the survey is required to monitor the internal consistency of the redshift determination.
- There are no known problems in achieving a repeatable 30 km/s redshift error.

Requirement 13: Requirement on systematic redshift errors in redshift measurements. A nominal figure of a mean offset of less than 10 km/s is desirable for Galactic structure but it is unclear how to measure/test this.

- There is no mechanism in place to test and verify the external accuracy of galaxy redshifts. Comparison of emission line and absorption line redshifts show a mean systematic difference of approximately 3 km/s.



Requirement 14: Correctly classify 95% of quasars (defined as one emission line with EW $>$ 10 A and i$<$19.5). Quasars not classified as such will be assigned a class "unknown". [The definition of a QSO has been revised to be one where we classify a spectrum as a QSO by eye for a set of test spectra].

- Pipeline classification of "eyeballed" QSO spectra indicates a current classification success rate of $>$95%. The input of the QSO working group in classifying the existing spectra is required to verify this result for a large set of data.
- These results are based on the analysis of plates 284, 292, 296, 306, 308 from the March-June dark runs using 1d_3c.3 of the 1D pipeline.

Plate	MJD	$SN^2_{g'(1,2)}$	$SN^2_{r'(1,2)}$	$SN^2_{i'(1,2)}$
284 48 out 48 of (100%)	51662	60.1 63.1	76.8 75.8	69.0 66.9
292 50 out of 50 (100%)	51609	101.0 103.9	105.3 105.1	91.3 95.3
296 35 out of 36 (97.22%)	51665	73.0 71.5	83.0 72.5	69.4 58.9
306 48 out of 48 (100%)	51690	108.0 112.7	127.5 140.2	120.5 134.8
308 71 out 72 of (98.6%)	51662	124.3 140.4	147.9 152.8	121.9 130.5

Requirement 15: A maximum of 1% of Galactic stars will be assigned redshifts >0.01 (3,000 km/s) and have redshifts that differ by more than 1 sigma from 0.0 [The requirements for stars require redefinition to allow for Galactic structure].

- The visual inspection and classification of spectra shows that >94 % of stellar spectra are classified as such.

Plate	MJD	$SN^2_{g'(1,2)}$	$SN^2_{r'(1,2)}$	$SN^2_{i'(1,2)}$
284 40 out 42 of (95.2%)	51662	60.1 63.1	76.8 75.8	69.0 66.9
292 65 out of 69(94.2%)	51609	101.0 103.9	105.3 105.1	91.3 95.3
296 36 out of 36 (100 %)	51665	73.0 71.5	83.0 72.5	69.4 58.9
306 51 out of 52 (99.4 %)	51690	108.0 112.7	127.5 140.2	120.5 134.8
308 105 out of 108 (97.2%)	51662	124.3 140.4	147.9 152.8	121.9 130.5

- These results are based on the analysis of plates 284, 292, 296, 306, 308 from the March-June dark runs using 1d_3c.3 of the 1D pipeline.
- Improvements in the classification will be made by the addition of hot and cool stellar templates.

Requirement 16: The redshifts of BAL QSOs will be determined to an accuracy of 0.02 and for non BAL QSOs 0.005.

- Verification of the BAL QSO redshift accuracy requires the input of the QSO working group and has not been tested. For all QSOs in Plate 353 the redshift dispersion is 0.0023 (37 QSOs).
- The status of this requirement is not fully determined.

Requirement 17: At least 3 bright (15th magnitude) calibration stars with smooth spectral energy distributions (F subdwarf) must be spectroscopically observed per plate.

- At least 6 spectrophotometric standards are observed - distributed about a plate.
- The Plate product assigns at least 8 spectrophotometric standards to fibers.
- There are no known problems with selection of spectrophotometric standards.

Requirement 18: The position of each fiber, relative to the center of its target must be determined with an accuracy of <0.5" for over 85% of fibers.

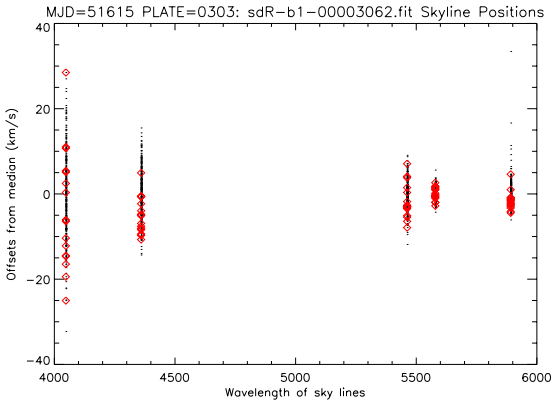
- The S/N of the target spectra show no systematic variation across a plate to indicate that the fibers are incorrectly positioned. The focal plane of the telescope needs to be properly mapped. The procedures for this are in place but the observations have not yet been undertaken. Reduction of these data will be completed over the summer.
- Monitoring of the the fiber positioning will be achieved by periodic observations of FASTT fields.
- There are no known problems with fiber positioning.

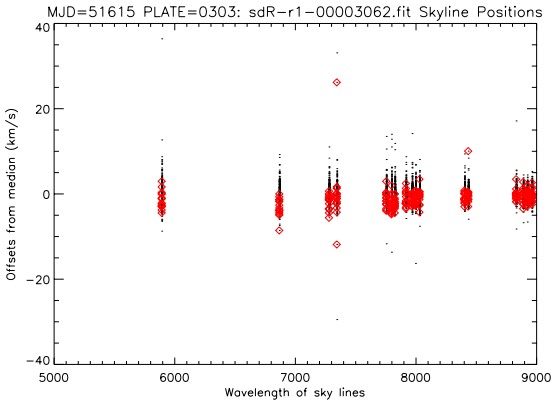
ADDITIONAL REQUIREMENTS:

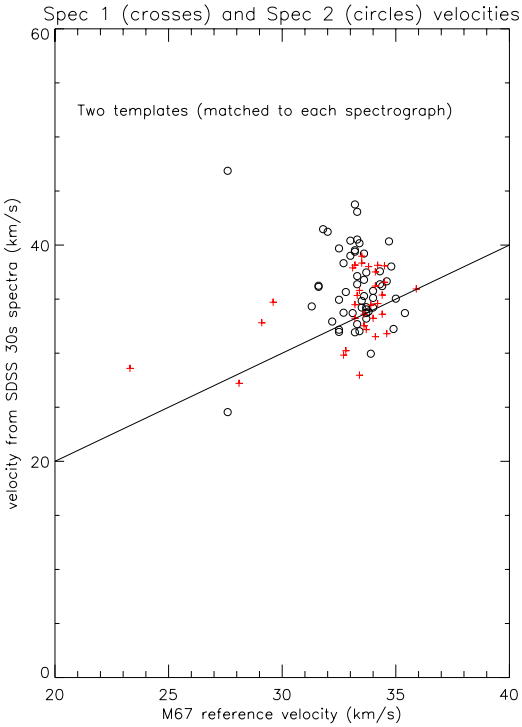
Requirement 19: RMS deviation of the measured wavelength scale from sky lines should be less than 0.1 A (blue) and 0.2 A (red) for all fibers over the full spectra range.

- Rms deviation is <0.1 A in blue and red.
- Data used to generate these numbers are the March-May spectroscopic observations and the M67 data reductions.

- Plot of rms wavelength solutions and the velocity standards.





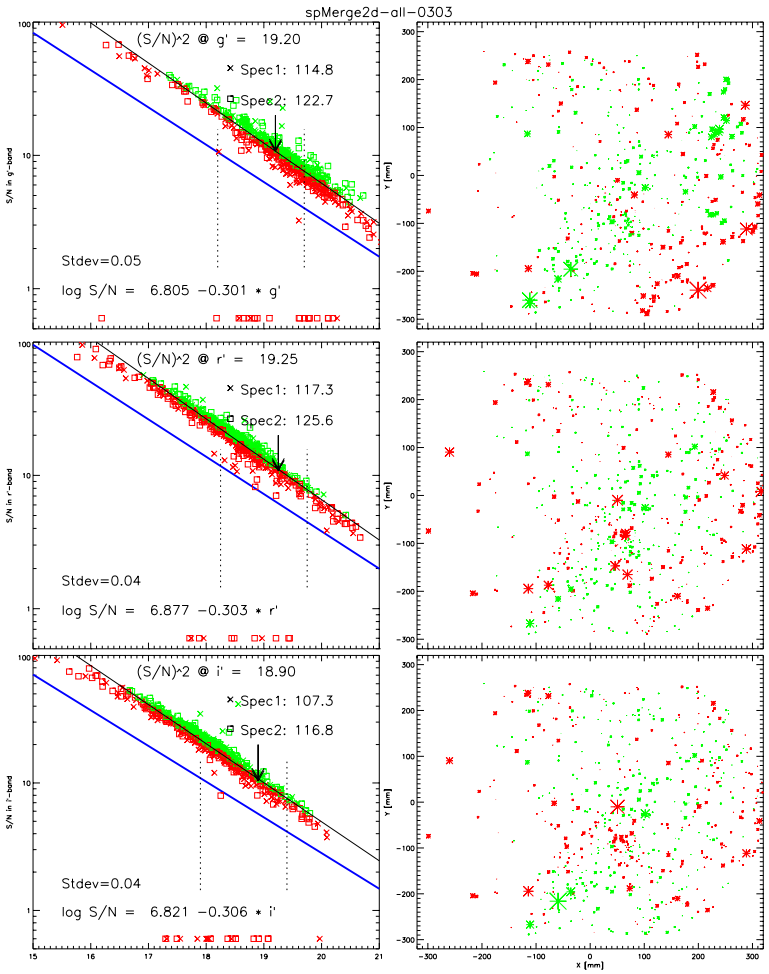


- The deviation in the wavelengths of sky lines is an output of the spectroscopic pipeline and will be monitored by the spectroscopic data analyst.
- There are no known problems with wavelength solutions for the sky lines.

Requirement 20: The S/N of 99% of spectra per plate must reach a S/N limit of 9 per pixel to be accepted for reduction.

- Spectroscopic observations are repeated until the plates meet the desired S/N criteria. The S/N limit has not been defined such that the redshifts meet the desired accuracies and the survey can proceed at the desired rate of 200,000 redshifts per year. The S/N limit needs to be defined by the Galaxies and QSO WGs.
- Data used to generate these numbers are the March-May spectroscopic observations.

- Plot of S/N per plate for plate 0303.



- The S/N of the spectra is derived nearly realtime on the mountain using a subset of the 2D pipeline package. Plates are defined as done when they pass the S/N limit.
- There are no known problems with S/N monitoring.